

# Resistivity of Candidate Electrode Materials Status Report

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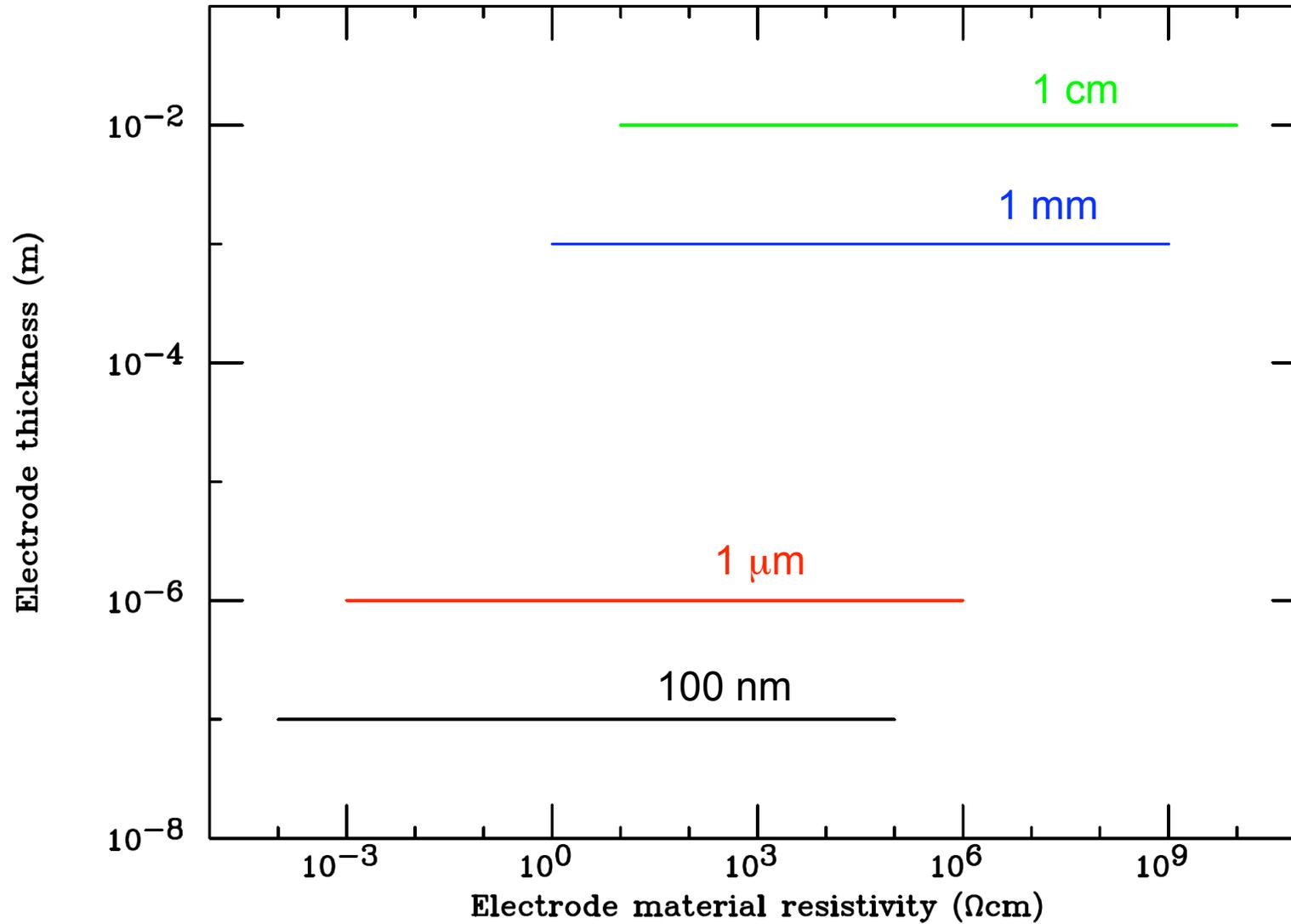
# Requirements for HV electrode material

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- Electrical resistivity
  - Eddy current heating
  - Johnson noise
  - Reasonable charge-up time
- Hardness
- Interaction with neutrons
- Others
  - Piezo electric coefficient
  - .....

# Acceptable resistivity (EDM collaboration meeting, Oct 7, 2007)

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## Requirements — Resistivity

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If only the volume resistivity contributes

$$10^1 \Omega < \frac{\rho_v}{t} < 10^9 \Omega$$

If taking the surface resistivity into account, as well

$$10^1 \Omega < \rho_{eff} < 10^9 \Omega$$

$$\frac{1}{\rho_{eff}} = \frac{1}{\rho_v / t} + \frac{1}{\rho_s}$$

# What can we use?

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- Metal
  - Resistivity is typically  $10^{-6} \Omega\text{cm}$  at RM. The resistivity goes down as the temperature goes down due reduced phonon scattering. (Low temperature behavior dominated by the impurity.)
- Semiconductor
  - Resistivity goes as  $R(T) = \alpha \exp(\Delta E/2kT)$
  - The low temperature behavior can be somewhat controlled by doping
- Carbon resistor
  - Pure carbon is not semiconductor. The negative R-T characteristics of commercial carbon resistors results from their production process, which consists of pressing and sintering fine carbon particles together with some glue. The resistance is probably mostly determined by the contact resistance between the particles and by composition. As a result, the resistance of carbon resistors changes from sample to sample....  
(quoted from Pobell)
- Candidate material
  - Carbon filled plastic
  - Thin coating of alloy? ( $\rho_V \sim 10^{-4} \Omega\text{cm}$ )

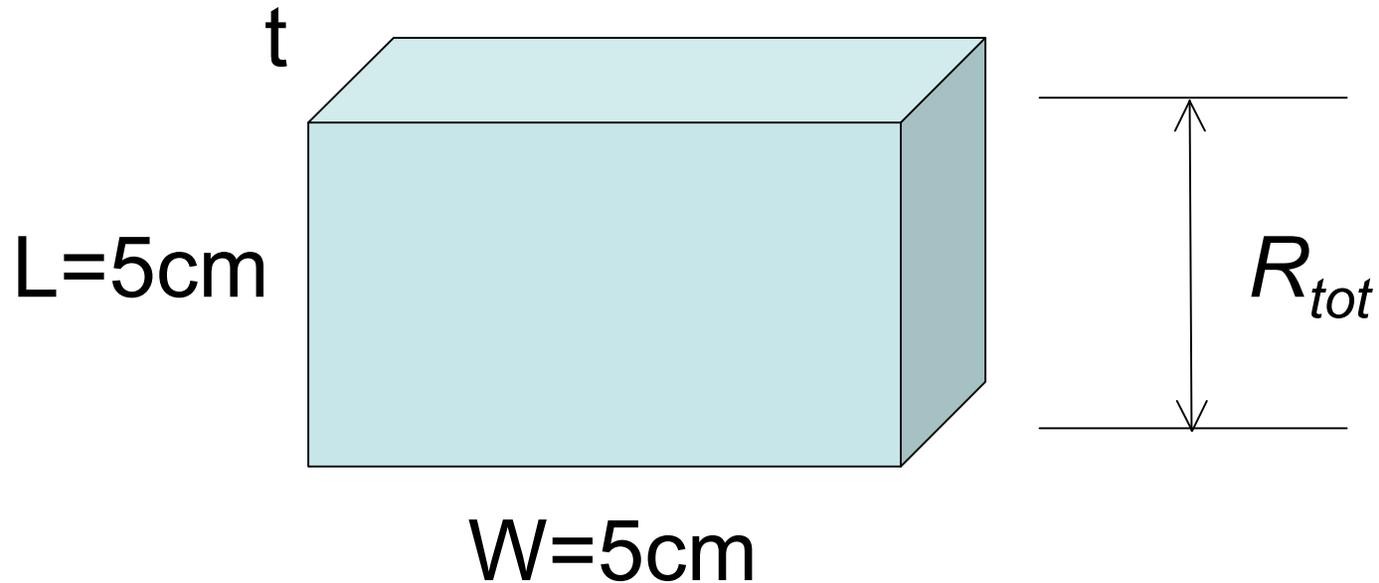
## HV candidate materials

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- Torlon 4435
  - $\rho_V=2 \times 10^7 \text{ } \Omega\text{-cm}$  and  $\rho_S=6 \times 10^6 \text{ } \Omega$  at room temperature
  - Sample thickness: 0.13", 0.23", 0.42"
- Semitron Esd 410C (graphite loaded Ultim)
  - $\rho_V=10^3 \text{ } \Omega\text{-cm}$  at room temperature
  - Sample thickness: 0.5", 1.0"
- Acrylic coated with graphite spray?

## Resistivity measurement

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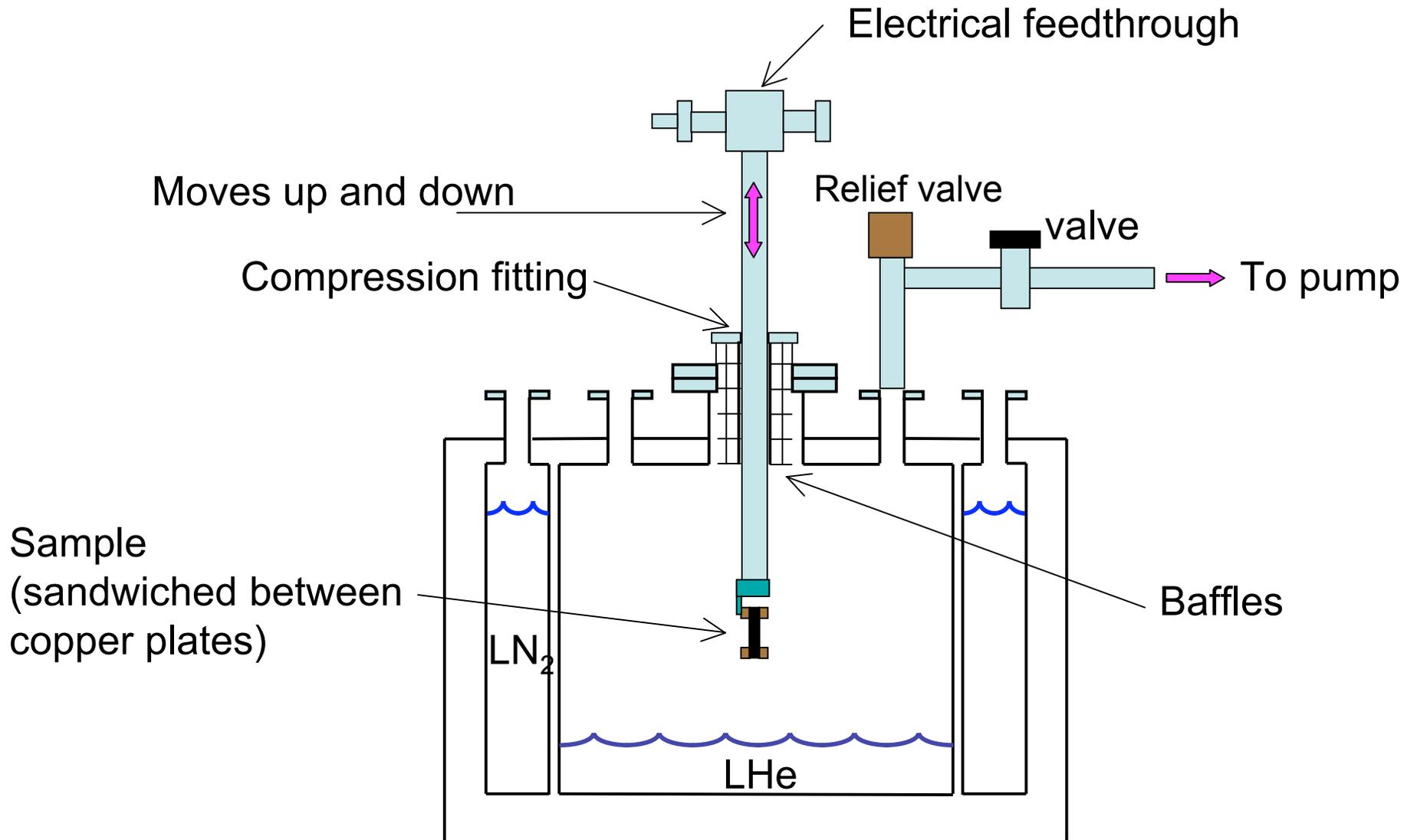
$$\frac{1}{R_{tot}} = \frac{1}{R_v} + \frac{1}{R_s}$$

$$R_v = \frac{L}{W} \frac{\rho_v}{t}$$

$$R_s = \frac{L}{W} \rho_s$$

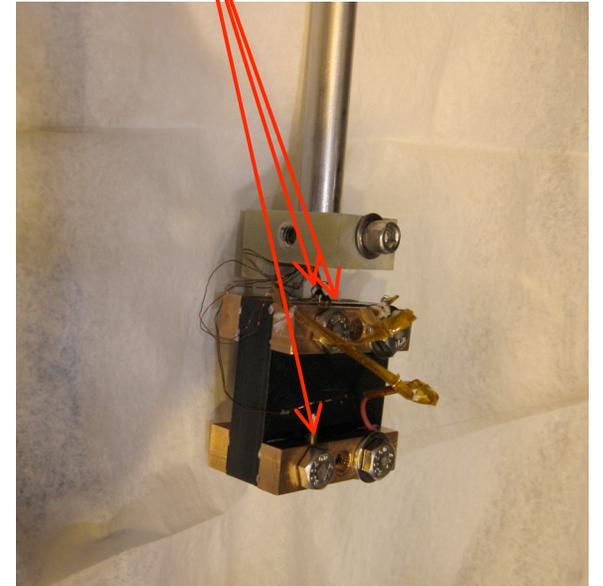
# Schematic

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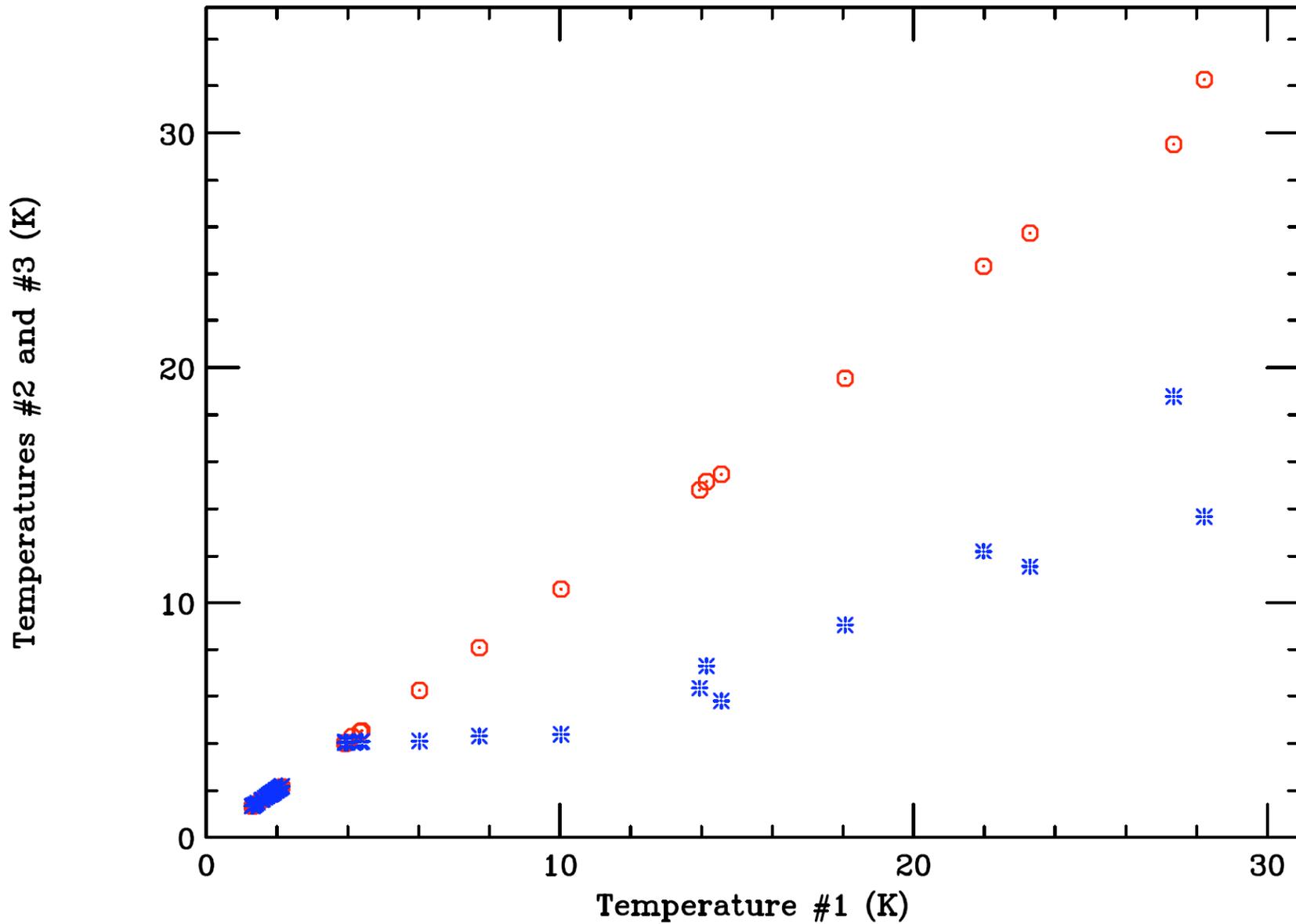


RuO temperature sensors



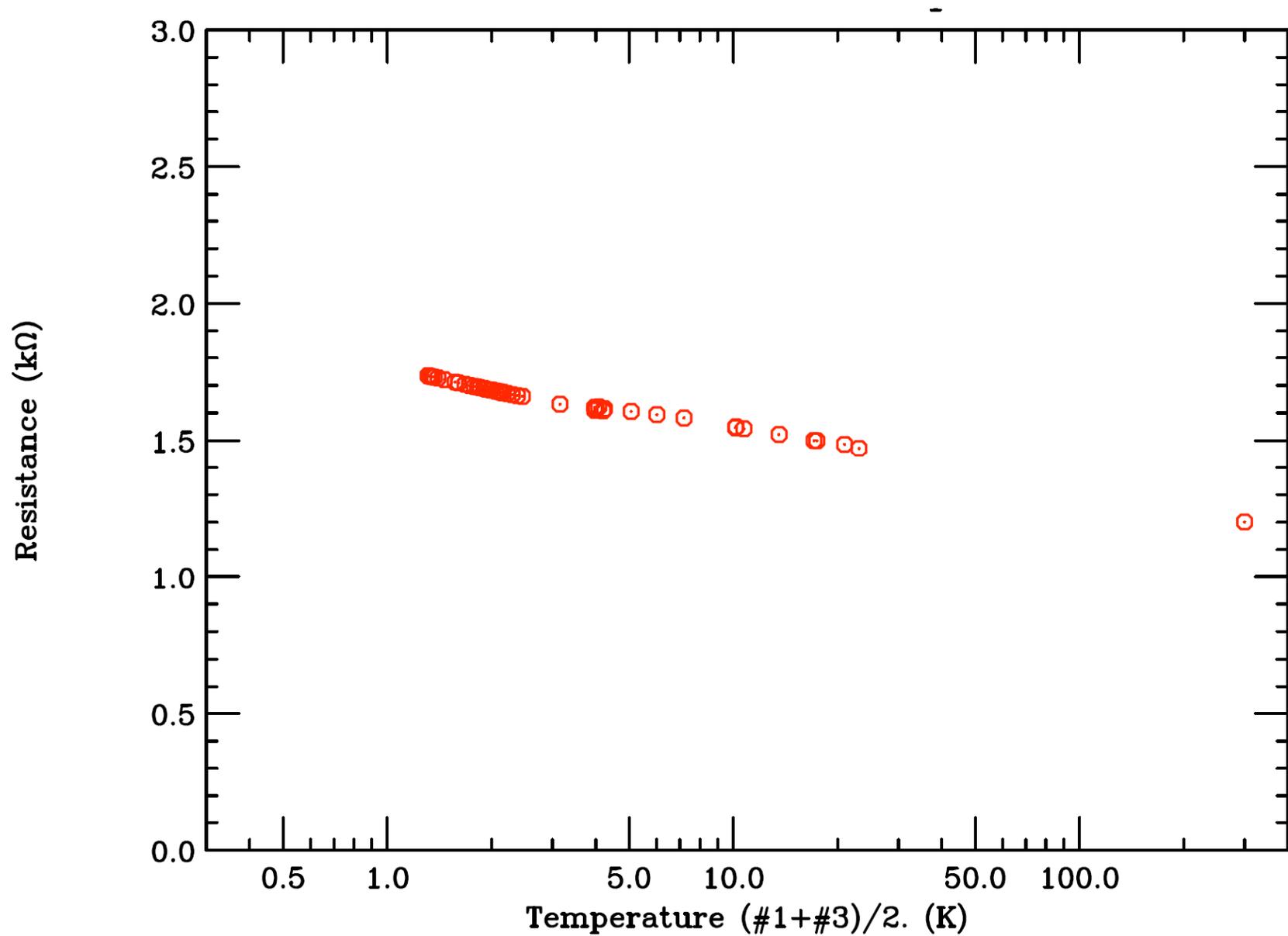
# Preliminary results: Torlon 4435, 0.23" thick

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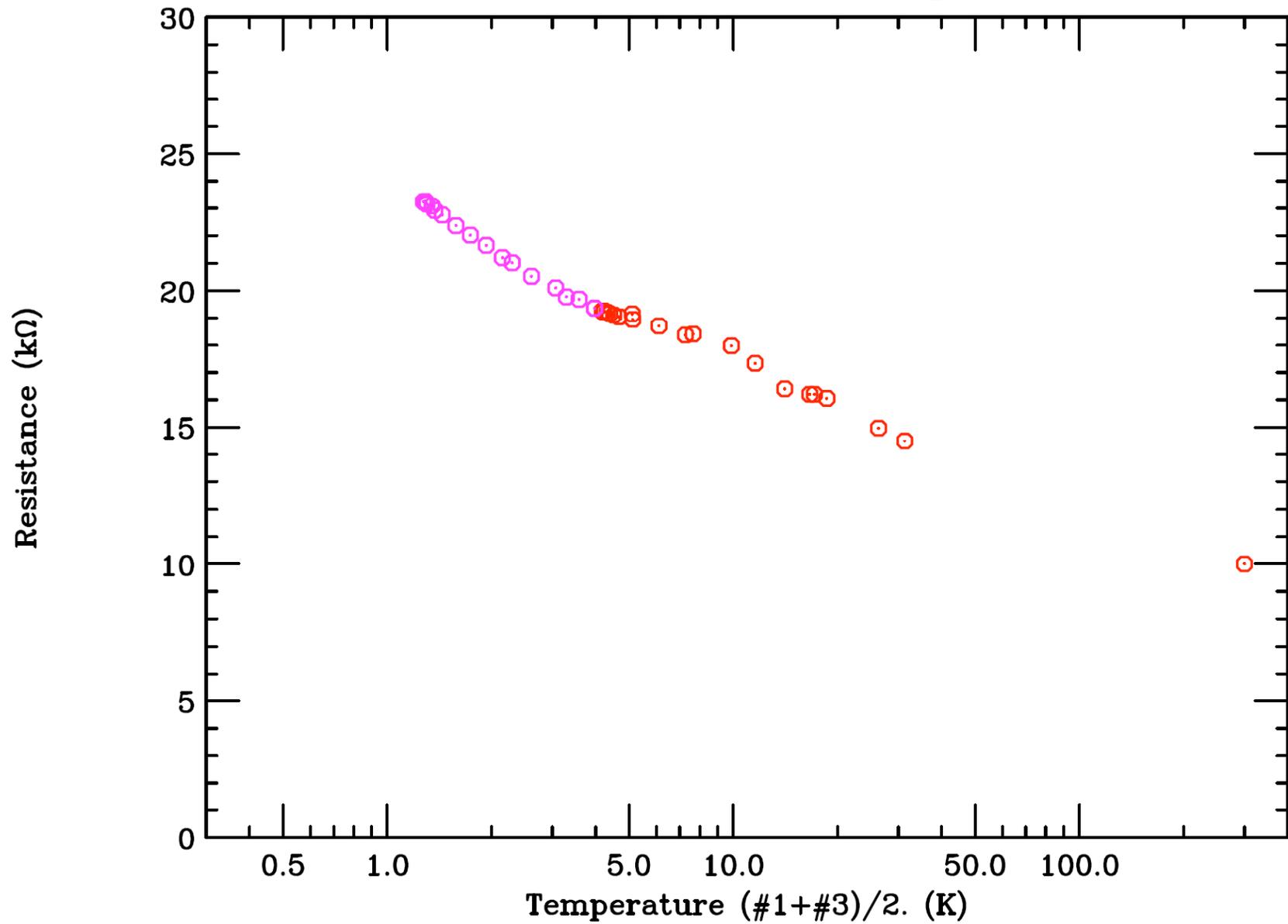
## Preliminary results: Torlon 4435, 0.23" thick

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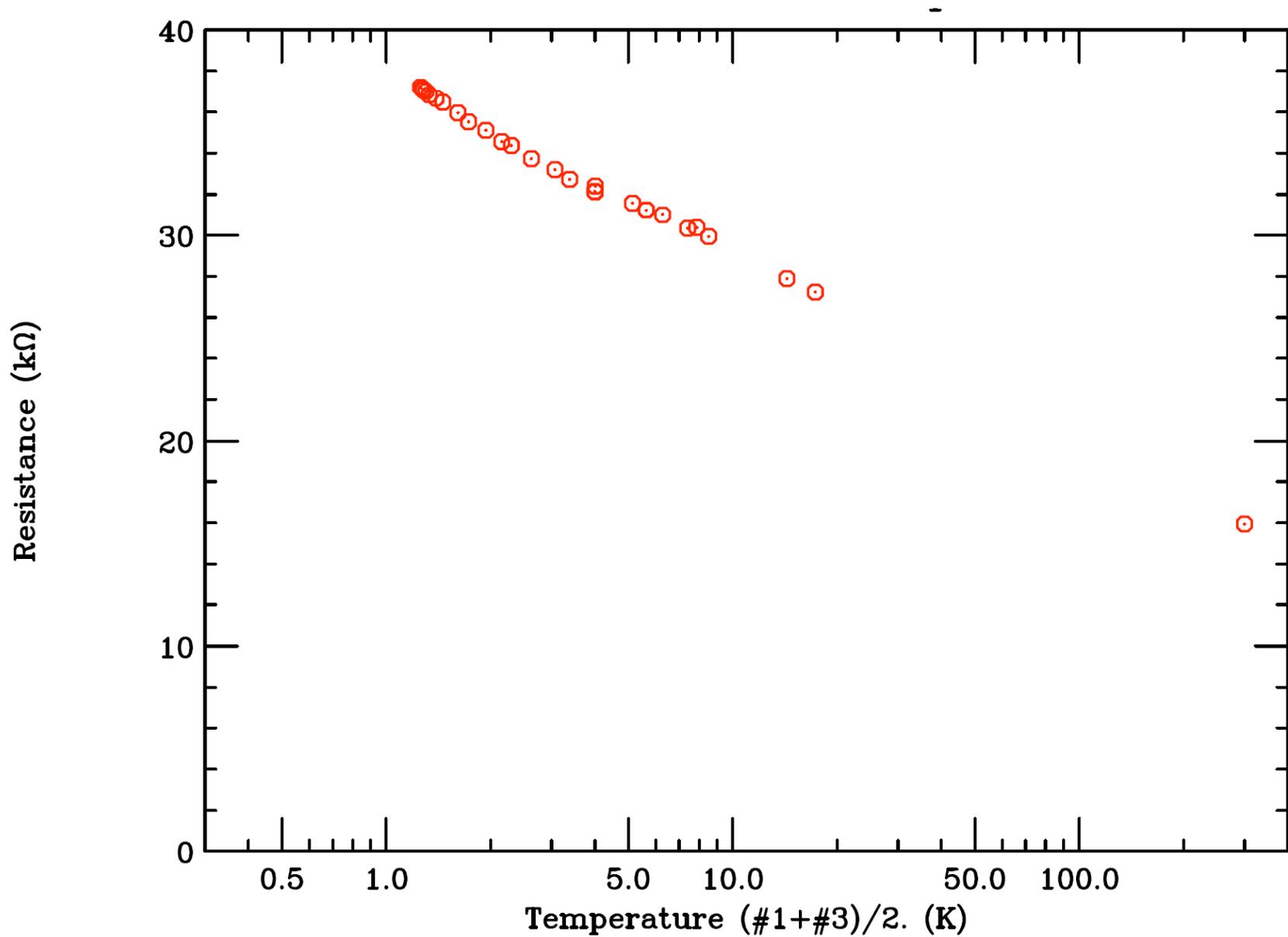
## Preliminary results: Torlon 4435, 0.42" thick

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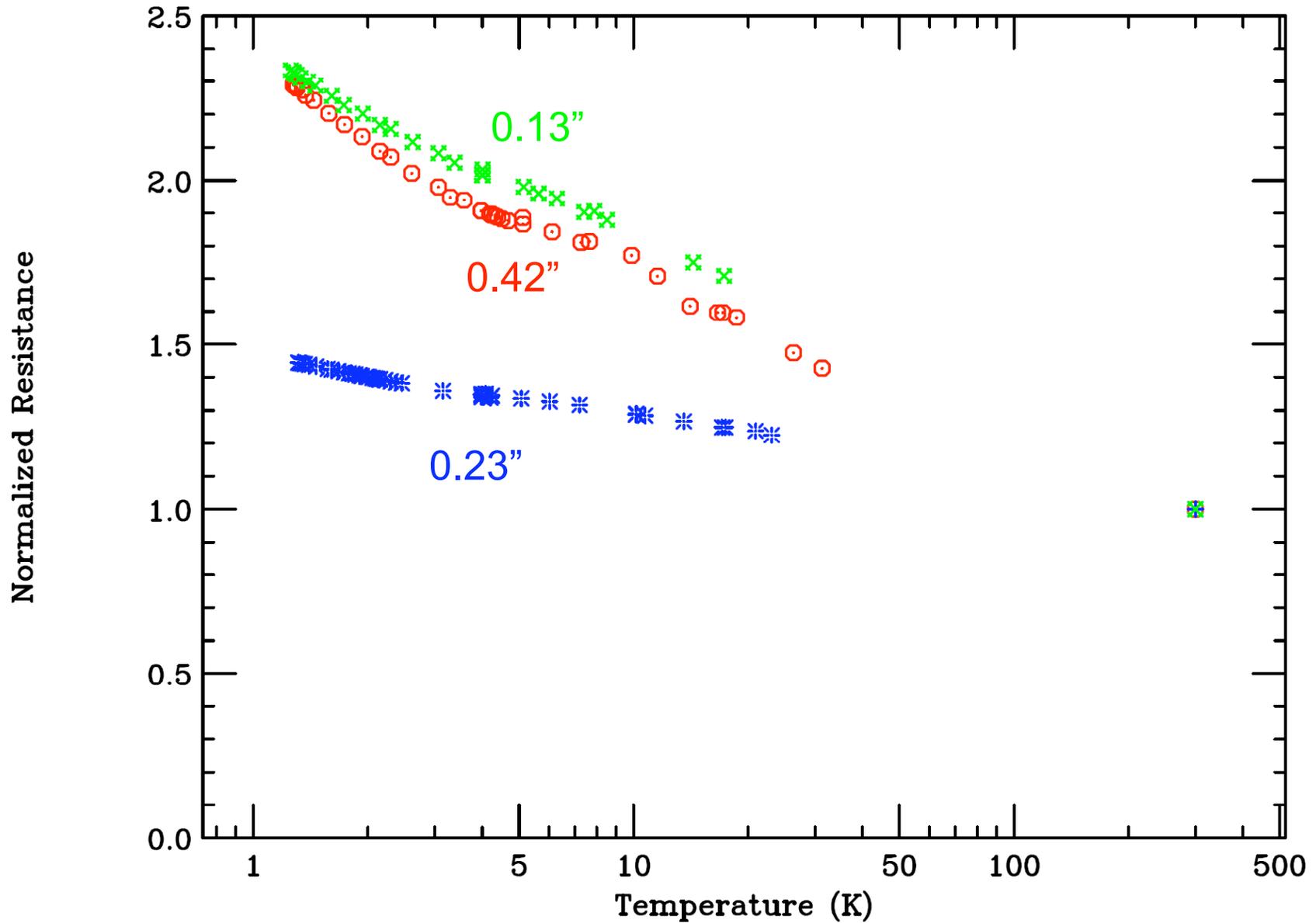


## Preliminary results: Torlon 4435, 0.13" thick

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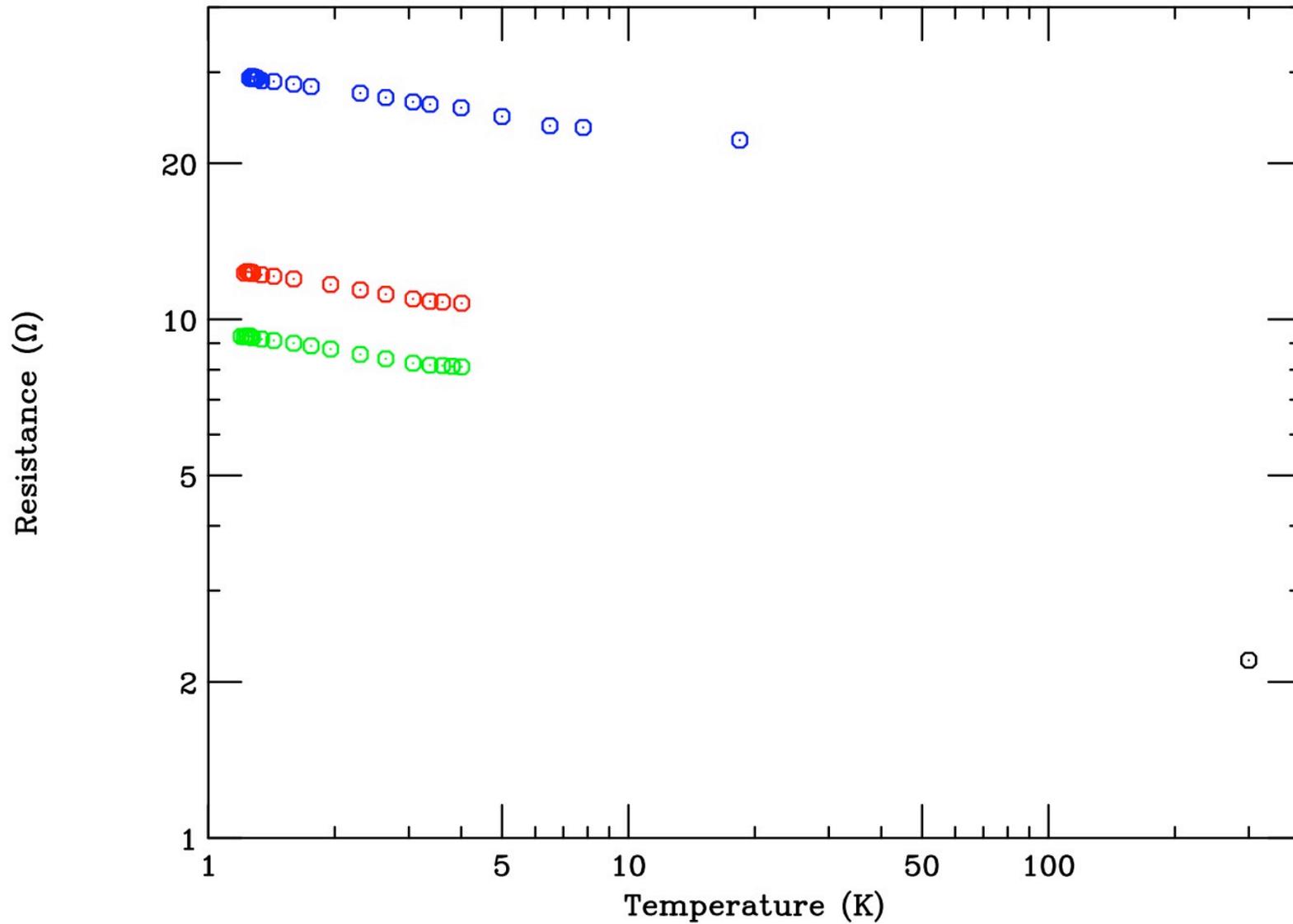


# Preliminary results: Torlon 4435, normalized comparison



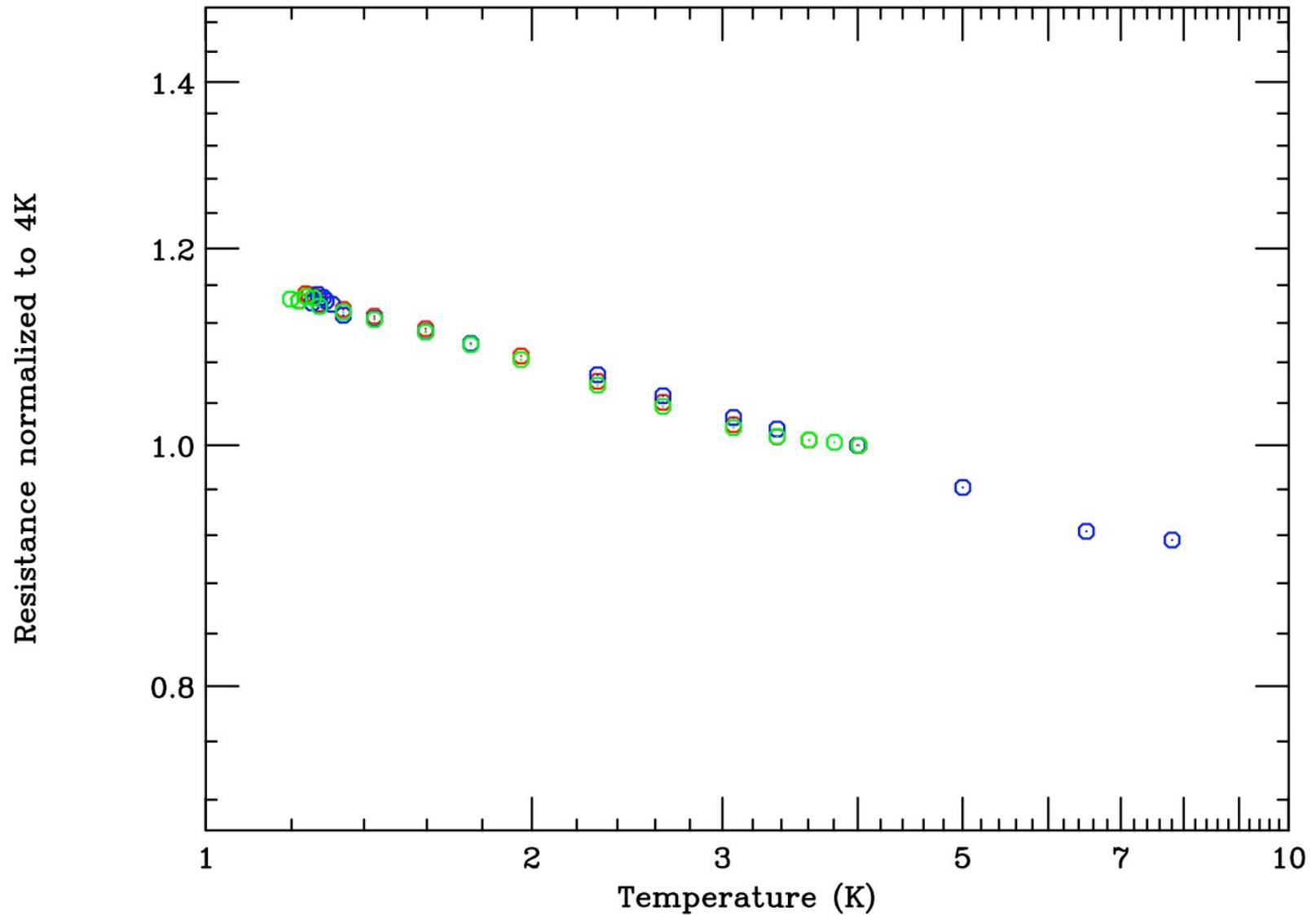
# Preliminary results: Semitron Esd 410, 0.52" thick

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## Summary

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- Preliminary tests indicate that both Torlon 4435 and Semitron Esd 410C seem to have resistivities in the right ball park .
- Need to understand the dependence on orientation and other factors.
- Will perform tests at temperatures down to 0.3K, using either DR or 3He cryostat.
- Will perform HV test with small electrodes before making electrodes for Josh' HV test apparatus.